ILLINOIS NATURAL HISTORY SURVEY

TECHNICAL REPORT

2007 Outbreak of Human Pruritic Dermatitis in Chicago, Illinois Caused by an Itch Mite, *Pyemotes herfsi* (Oudemans, 1936) (Acarina: Heterostigmata: Pyemotidae)

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Introduction

In August of 2007, a request was received from the Illinois Department of Public Health for assistance in identifying the causative agent of an unusually large outbreak of unexplained "insect bites" from neighborhoods in Cook and Du Page Counties. The causative agent was suspected to be an itch mite, *Pyemotes herfsi* (Oudemans, 1936), that had been implicated in outbreaks during 2004 and 2005 in parts of Kansas, Nebraska, Missouri and Texas; however, leaf and sticky card samples sent to entomologists in Nebraska did not yield an identification of the causative agent.

The specific objectives of the work reported herein were: 1) to conduct field sampling of oak leaf galls and other suspected habitats to isolate the causative agent of the outbreak, 2) to identify the amplifying insect host of *Pyemotes* mites, if these prove to be the causative agent, and 3) to obtain independent confirmation of identification of the causative agent from a second entomologist who specializes in the appropriate group of mites or other arthropods.

Methods

Material examined included samples submitted by University of Illinois Extension (UIE) and Illinois Department of Public Health (IDPH) personnel: mite specimens dissected out of oak leaf galls from Park Ridge, IL, and collected into alcohol; and samples of oak leaves and twigs collected from Park Ridge, IL and Morton Arboretum (Downers Grove, IL).

Phone interviews with UIE and IDPH personnel were conducted regarding the locations in which bites were being reported, the circumstances under which the bites were being experienced, the type of vegetation in locations where bites were being reported, and the frequency with which leaf galls were observed on trees in these locations. Clients calling with questions were similarly interviewed.

In addition to samples submitted by UIE and IDPH personnel, a field collecting trip guided by IDPH personnel was made to neighborhoods in Downers Grove and Hinsdale, IL, were numerous cases of bite rashes had been reported. Samples of tree leaves, twigs and soil/litter were collected from trees and returned to the lab for examination. Homeowners were interviewed regarding the circumstances under which they experienced bites and any other observations they could offer.

Leaves and twigs were examined under a dissecting microscope (8-50x). Galls on leaves and cicada eggnests in twigs were photographed using a digital camera and opened using a dissecting knife. Some leaves and twigs were subjected to a bulk rinsing and wet sieving with 70% ethanol; the washings were concentrated on a 270-mesh (53 μm) sieve, rinsed into Petri dishes with 70% ethanol, and examined under a dissecting microscope. Representatives of all invertebrates found were transferred to 70% ethanol for preservation and further examination.

Laboratory cultures of pyemotid mites were established by transferring live field-collected non-physogastric female mites to pupae of *Pachysomoides* sp. (Hymenoptera: Ichneumonidae) collected from a nest of *Polistes* sp. (Hymenoptera: Vespidae) wasps. Parasitized pupae were held at room temperature on dry filter paper in disposable Petri dishes. Development of mites was observed daily under a dissecting microscope and photographed using

a digital camera. Representative specimens of both male and female mites were transferred to alcohol for preservation and further examination.

Representative specimens of mites were mounted in Hoyer's mounting medium on glass microscope slides, covered with 12-mm round cover slips and placed on a slide-warming table. After curing for a minimum of two weeks, slides were sealed by ringing the edge of the cover slip using red glypt insulating varnish. Slide-mounted specimens were examined using compound microscopy (100-600x) under phase contrast and differential interference contrast illumination, and photographed using a digital imaging system.

A literature review was undertaken to obtain information on the biology and ecology of pyemotid mites and periodical cicadas, and to obtain primary descriptions and illustrations of known species of *Pyemotes* mites (Table 1).

Pyemotid mites were identified to species using published keys and primary descriptions of known species. Representative specimens of identified mites were sent to Dr. John Moser, Emeritus Research Entomologist, U.S.D.A. Forest Service, for confirmation of identification. Representative specimens are deposited in the U.S.D.A. Forest Service Southern Research Station collection of mites associated with bark beetles at Pineville, and in the insect collection of the Illinois Natural History Survey.

Results and Discussion

The symptoms of the "insect bites" reported in the 2007 Illinois outbreak included an intensely itchy red welt 2-5cm in diameter surrounding a small, central pustule (Fig. 1), usually appearing on the upper torso, head, neck or arms. With scratching, this pustule was frequently excoriated, creating an open would with the potential for becoming secondarily infected. People who developed the rash never recalled the sensation of being bitten, but invariably developed symptoms several hours after being outdoors. The rash and intense itchiness peaked after several days, and lasted for as long as two weeks. Anti-itch treatments such as calamine lotion and cortisone creams did not provide appreciable relief from itching.

These symptoms were virtually identical to those experienced in a similar outbreak of bites that occurred during August and September of 2004 and 2005 in Kansas, Missouri, Nebraska and Texas; tens of thousands of people were affected. This outbreak was eventually associated with a pyemotid mite, *Pyemotes herfsi*. In a publication arising from the investigation of this outbreak, Broce et al. (2006) reported that this mite was thought to be introduced from Europe and, like all pyemotids, is an external parasite of various insects. In the 2004-05 outbreaks, the host insects were *Contarinia* gall midges forming leaf margin roll galls and vein pocket galls on pin oaks (*Quercus palustris*) that were common in the landscape vegetation in neighborhoods where bite outbreaks were reported. Searching mites falling out of trees onto people below explained why bites most often appeared on the upper parts of the body. The similarity of the symptoms in the 2007 Illinois outbreak to those in the 2004-05 outbreaks led IDPH personnel to suspect that the same causative agent was involved, but initial sampling failed to yield positive species identification of the causative agent by entomologists from Nebraska, although 4 pyemotid mites were recovered from sticky traps.

On August 15, 2007, Phil Nixon, UIE, submitted for examination mites in alcohol that he had dissected out of galls on oak leaves he had received from colleagues in Chicago. None of these

mites were pyemotids, and they were not considered to be candidate causative agents for bite rashes. Undissected field samples of leaves were requested.

On Friday, August 17, 2007, Phil Nixon submitted four samples of pin oak and burr oak leaves and twigs from Park Ridge, IL, and four samples of pin oak and burr oak leaves and twigs from Morton Arboretum in Downers Grove, IL, all collected on August 15. Among all of these samples, only two leaves from a Park Ridge sample had leaf margin roll galls (Fig. 2), and out of twelve galls, 29 live unparasitized midge larvae, one predatory mesostigmatid mite and several tarsonemid mites were recovered, but no pyemotid mites. None of the recovered invertebrates were considered to be candidate causative agents of bite rashes. However, over the weekend after handling these leaf and twig samples, I developed two bite rashes: one on my arm (Fig. 1) and one on my chest. On Monday, August 20, a more labor-intensive alcohol wash process was conducted with two of the Park Ridge pin oak samples. From these two samples, 401 mites were recovered, including 17 pyemotid mites (16 females, 1 male). Only the pyemotid mites were considered to be candidate causative agents. Eight pyemotids (7 female, 1 male) were fixed on permanent microscope slides for further examination. The females keyed out to the *Pyemotes ventricosus* group (*P. anobii*, *P. beckeri*, *P. herfsi* (=*P. zwoelferi*), *P. schwerdtfegeri*, *P. tritici*, *P. tuberculatus*, *P. ventricosus*). No morphological characters have been identified to distinguish between females of species in this group; species identification requires examination of male specimens, which typically make up ~5% of populations. The single male collected from the alcohol washes was in poor condition and could not be identified with certainty.

A field collecting trip, guided by Barb O'Meara, IDPH, was conducted on August 24 to secure additional material, including live mite specimens, and to identify possible amplification hosts. Samples were collected in Downer's Grove and Hinsdale, IL, in neighborhoods where many cases of bite rashes were reported. In Downers Grove, 15 leaf and twig samples from 15 trees (pin oak, burr oak, ash, Norway maple, silver maple, European basswood, elm, black locust, spruce, ash, hackberry, river birch, horse chestnut, hickory) and one soil/litter sample were collected. This was the location where sticky traps had yielded 4 unidentified pyemotid mites. Again, it was observed that Pin oaks were not common in the sampled neighborhood, with a cluster of trees occurring in only one yard. Leaf margin roll galls and vein pocket galls were not abundant; I estimated them to be <1 in 1000 leaves. In Hinsdale, a resident who was interviewed reported continuing to experience bites up to the present. Five leaf and twig samples (Burr oak, elm, crab apple, Norway maple, sycamore) were collected from this resident's yard. No pin oaks were present in this or adjacent yards. In both neighborhoods, "flagging" (dead branch tips) and numerous egg scars from the 2007 emergence of Brood XIII periodic cicadas, *Magicicada* spp., were observed on virtually all of the terminal branches of all of the trees examined.

Observations, interviews and examination of samples from this collecting trip confirmed impressions from earlier interviews and field reports of UIE and IDPH personnel that suggested important differences between the 2004-05 outbreaks in Kansas and Nebraska and the 2007 Illinois outbreak: 1) abundance of oak leaf margin roll and vein pocket gall midges–the amplification hosts in the 2004-05 outbreaks–was very low, perhaps 1 in 1000 pin oak leaves with galls, compared to many or most leaves with at least one gall in the 2004-05 outbreaks; 2) dissection of leaf margin roll galls from the Downers Grove site revealed healthy, unparasitized gall midge larvae; and 3) bite rashes were being reported from neighborhoods in which pin oaks were rare or absent. These observations suggested that, if pyemotid mites were the causative

agent of the bite rash outbreak, their populations were probably amplifying, not on *Contarinia* oak gall midge larvae, but on a different insect host.

A number of interviewees had inquired whether the outbreak of bite rashes may have been related in some way to the emergence periodical cicadas earlier in the year. At first, this was discounted because the adult cicadas had died off many weeks before the first reports of bite rashes, and cicada nymphs are subterranean. In the absence of hosts, *Pyemotes* mites are short-lived (on the order of days), and the fact that bite rashes most frequently appeared on the upper parts of the body suggested that the host was arboreal. However, on the collecting trip, "flagging" – dead branch tips resulting from heavy oviposition into terminal braches by periodical cicadas earlier in the year – and numerous oviposition scars of periodical cicadas on most terminal branches of all of the tree species sampled were observed at both field locations. Sampling was conducted to include cicada eggnests.

Adult periodical cicadas emerge from the soil when it warms to a threshold temperature, usually in May or early June, and lay their eggs in "egg nests" on tree branches during June (Fig. 3). The adults then die off. Each eggnest is composed of two egg chambers, each holding 10-20 eggs (Fig. 4). The eggs remain in the eggnests for 6 to 10 weeks, after which the nymphs emerge, fall to the ground and immediately burrow into the soil where they spend the next 17 years feeding on sap sucked from tree roots. Periodical cicada eggs were thus present in the right location, at the right time, and in large enough numbers to serve as amplification hosts for *Pyemotes* itch mites.

Dissection of cicada eggnests revealed that *Pyemotes* mites were, indeed, utilizing periodical cicada eggs as hosts (Fig. 5). Of nine eggnests dissected, pyemotid mites were found in five (21 *Pyemotes* mites were recovered, including 4 males, 11 normal females, and 6 physogastric females), and eight eggnests showed evidence of parasitism (dead eggs or cicada nymphs). Out of 232 eggs in the eggnests, a total of 84 dead eggs and nymphs were found, a mortality rate of 36%. In some cases, complete eggnest failure was observed (Fig. 6), as dead eggs or nymphs at the "mouth" of the eggnest appeared to block egress by subsequently hatching nymphs. This rate of mortality in the eggnest, attributable to parasitization by pyemotid mites, is unusually high (Dr. John Cooley, University of Connecticut, personal communication).

A review of the literature indicated that mites of the *P. ventricosus* group are not host-specific. Searching female pyemotid mites found in cicada eggnests were transferred to live pupae of *Pachysomoides* sp. (Hymenoptera: Ichneumonidae) in plastic Petri dishes and held under ambient laboratory conditions. Almost immediately upon transfer to the pupae, mites stopped searching and pressed their mouthparts to the cuticles of the pupae. After 4 days, the female mites had become physogastric (Fig. 7), and after 10 days, the physogastric females started giving birth.

Representative male and female mites collected from cicada eggnests and cultured in the lab from field-collected mites were mounted on permanent glass slides, photographed (Figs. 8, 9) and, using appropriate keys and original species descriptions, were identified as *P. herfsi* (Oedemans, 1936). Representative slides were forwarded to by Dr. John Moser of the USDA Forest Service, a specialist in pyemotid mites, and he confirmed this identification.

A review of the literature revealed that *P. herfsi* is not new to North America, as suggested by Broce et al. (2006); *P. herfsi* was found in Colorado in 1956 (Broce et al., 2006), and in Utah in 1982 (Titayavan and Davis, 1988). Furthermore, *P. herfsi*, originally described from

specimens parasitizing clothes moths in Germany, has been found parasitizing a range of insect species in at least 5 insect orders and 9 families occupying a range of habitats (Table 2). The 2004-05 Kansas-Nebraska outbreak produced the only documented record of *P. herfsi* parasitizing Diptera, let alone oak leaf gall midges; the common name "oak leaf itch mite" suggests a specificity that is somewhat misleading. No previous confirmed reports of *P. herfsi* parasitizing Cicadidae, including cicada eggnests, were found. Most interesting, though, is a report by Marlatt (1898)–preceding the original description of *P. herfsi* by three decades–that "the mite most commonly found with the eggs of the [Periodical] Cicada is *Pediculoides ventricosus*." This report was based on material collected in 1885 in Michigan, Virginia and the District of Columbia. *Pediculoides ventricosus* is now known as *Pyemotes ventricosus*, and it is also now recognized (Cross et al., 1975) that the name *P. ventricosus* has historically been applied to a number of similar species, including *P. herfsi*. Based on the illustration of a physogastric female pyemotid in Marlatt's report, the mite he found in periodical cicada eggnests belonged to the *P. ventricosus* species group, which includes *P. herfsi*. The possibility that *P. herfsi* has been present in North America for more than one hundred years, and may even be indigenous, cannot be excluded.

Examination of cicada egg nests collected at the end of August showed that most of the cicada eggs had already hatched; as a result, there were fewer and fewer hosts upon which new generations of mites could develop. In the absence of an alternative host, we would expect the incidence of bites and rashes to decline rapidly because the mites have a very short lifespan. Furthermore, this particular brood of cicadas (Brood XIII will not make an appearance again until 2024. If we assume that cicada eggs were the only insect host upon which *P. herfsi* populations associated with the Illinois outbreak amplified, we can predict that, in the absence of another suitable and abundant host occupying a well-sheltered microhabitat, we would not expect a significant recurrence of mites in 2008 or subsequent years.

Because pyemotid mites live in a sheltered environment, they cannot be controlled effectively with a contact insecticide. In stored grain products, they can be controlled with fumigation, but this is not practical when they are associated with an insect host in trees. An appropriate systemic insecticide applied to trees might be effective if it controlled a plant-feeding insect that was serving as a host–like the oak leaf gall midges–but such an insecticide has not yet been identified. Furthermore, in the case of cicada eggs, no plant feeding is taking place before the eggs hatch and the nymphs enter the soil, so a systemic insecticide would be ineffective.

The bites and rashes caused by pyemotid mites can cause considerable discomfort. Fortunately, they do not appear to present a significant health risk. Pyemotid mites are not known to transmit diseases in the way that some species of mosquitoes transmit West Nile virus, or that deer ticks that transmit Lyme disease. There is, however, a risk from secondary infection if the bite is scratched excessively, leaving an open wound.

Conclusions

1. The causative agent of the outbreak of bite rashes in the Cook and DuPage Counties in Chicago area of Illinois during August-September 2008 was *Pyemotes herfsi* (Oudemans, 1936), a polyphagous obligate ectoparasite of insects. This is the same species of mite that caused the Kansas-Nebraska bite outbreak in 2004-2005.

2. Identification of the causative agent was confirmed by Dr. John Moser, Emeritus Research Entomologist, U.S.D.A. Forest Service.
3. Voucher specimens are deposited in the insect collection of the Illinois Natural History Survey and in the U.S.D.A. Forest Service Southern Research Station collection of mites associated with bark beetles at Pineville, LA.
4. In the 2007 Illinois outbreak, the only insect found to be parasitized by *P. herfsi* in the field was the developing eggs of 17-year periodical cicadas, *Magicicada* spp. Brood XIII periodical cicadas emerged earlier in the year and laid large numbers of eggs in the terminal branches of many deciduous tree species in the outbreak area. It appears that this abundance of cicada eggs served as the host upon which populations of *P. herfsi* mites amplified to outbreak levels, unlike the Kansas-Nebraska outbreak in which the amplification host for *P. herfsi* was oak leaf gall midges.
5. The proposed common name "oak leaf itch mite" for *P. herfsi* is misleading and contributed to the delay in identifying the causative agent of the 2008 Illinois outbreak. Insects from at least 5 insect orders and 9 families occupying a range of habitats have been recorded as hosts for *P. herfsi*.
6. This is the first confirmed report of *P. herfsi* parasitizing cicada eggnests.
7. Contrary to recent reports, *P. herfsi* is not new to North America; it has been found in Utah in 1982 and in Colorado in 1956. A species of *Pyemotes* that, based on available data is indistinguishable from *P. herfsi*, was reported to be "the mite most commonly found" with periodical cicada eggnests among samples collected in 1885 in Michigan, Virginia and the District of Columbia. The possibility that *P. herfsi* has been in North America for more than one hundred years, and may even be indigenous to North America, cannot presently be excluded.

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Table 1. Species and Taxonomic Position of the Genus *Pyemotes*

Subcohort HETEROSTIGMATA

Superfamily PYEMOTOIDEA

Family PYEMOTIDAE Oudemans, 1937

Pyemotes Amerling, 1861 [Cross, 1975]
[=***Heteropus*** Newport, 1850]
[=***Pediculoides*** Targioni-Tozetti, 1878]

P. acridivorous Chinniah & Mohanasundaram, 1999
P. alastoris (Froggatt, 1894)
[=***Heteropus alastoris*** Froggatt, 1894]
P. amygdali Çobanoğlu & Doğanlar, 2006
P. anobii Krczal, 1959a
P. barbara Moser, Smiley & Otvos, 1987
P. beckeri Krczal, 1959a [Diagnostic, Yu & Liang 1996]
P. amygdale Çobanoğlu & Doğanlar, 2006
P. dimorphus Cross & Moser, 1975 [Diagnostic, Smiley & Moser 1984:11]
P. dryas (Vitzthum, 1923)
P. eccoptogasteri-pruni (Amerling, 1862) [type]
[=***Piemotes eccoptogasteri-pruni*** Amerling, 1862]
[=***Pediculoides tritici*** Targioni-Tozetti, 1878]
P. emarginatus Cross, Moser & Rack, 1981
P. giganticus Cross, Moser & Rack, 1981
P. herfsi (Oudemans, 1936)
[=***Pediculoides herfsi*** Oudemans, 1936]
[=***Pyemotes zwoelferi*** Krczal, 1963]
P. johnmoseri Haustov, in Khaustov, 1998
P. mandelshtami Khaustov, 1999
P. moseri Yu & Liang, 1996
P. muraiae Mahunka & Mahunka-Papp, 1998
P. parviscolyti Cross & Moser, 1971
P. pseudoscolyti Khaustov, 1998
P. rhynchitinus (Debey, 1849)
[=***Dermaleichus rhynchitinus*** Debey, 1849]
[=***Dermaleichus attelabrinus*** Debey, 1849]
P. schwerdtfegeri Krczal, 1959a
P. scolyti (Oudemans, 1936)
P. tritici (LaGrèze-Fossot & Montagné, 1851)
[=***Acarus tritici*** LaGrèze-Fossot & Montané, 1851]
[=***P. boylei*** Krczal, 1959b]
P. tuberculatus Cross, Moser & Rack, 1981
P. ventricosus (Newport, 1850)

Table 2. Insect hosts of *Pyemotes herfsi* (Oudemans, 1936) reported in the scientific literature.

Host	Habitat	Locality	Reference
Tineola biselliella (Lepidoptera: Tineidae)	clothes moth	Germany	Oudemans, 1936
Coleophora deauratella (Lepidoptera: Coleophoridae)	red clover seed heads	Germany	Krczal, 1963
Pectinophora gossypiella (Lepidoptera: Gelechiidae)	cotton bolls	UAR.	Tawfik & Wadallah, 1971
P. gossypiella (Lepidoptera: Gelechiidae)	cotton bolls	Egypt	Tawfik & El-Sherif, 1974
P. gossypiella (Lepidoptera: Gelechiidae)	??	Egypt	Bul-Nasr et al., 1978
Unknown host	feed mixing shed	Czechoslovakia	Samsinak, et al., 1979
Unknown host	stored grain products	Egypt	Al-Badry et al., 1980
Unknown host	dried flowers	Yugoslavia	Le et al., 1980
Unknown host	dust samples	Czechoslovakia	Samsinak & Vobrazkova, 1983
San Jose scale (Homoptera: Diaspididae) & *Aphytis vandenboschi* (Hymenoptera: Aphelinidae)	apple trees	Utah, USA	Titayavan & Davis, 1988
Melanaspis inopinata (Homoptera: Diaspididae)	Cotoneaster	Italy	De Lillo and Procelli, 1992
Rhyacionia buoliana (Lepidoptera: Tortricidae)	Conifer needles, buds	Chile	Broce et al., 2006
Hackberry nipple gall psyllid (Homoptera)	Hackberry nipple galls	CO	Broce et al., 2006
Contarinia sp. (Diptera: Cecidomyiidae)	oak leaf galls	KS MO NE OK TX	Broce et al., 2006
Magicicada spp. (Homoptera: Cicadidae) eggnests	deciduous trees	Illinois, USA	Zaborski (unpublished)

Figure 1. Example of the rash resulting from a bite by *P. herfsi*. The bite, which is not evident until 6-18 h after exposure, is characterized by a red welt or rash surrounding a small pustule at the bite site. The rash is extremely itchy and persists for as long as two weeks.

Photo credit: Ed Zaborski

Figure 2. Oak leaf margin roll galls caused by the oak leaf gall midge, *Contarinia* sp., on pin oak, *Quercus palustris*.

Photo credit: Ed Zaborski

Figure 3. Eggnest scars of periodical cicada, *Magicicada* spp., on pin oak.

Photo credit: Ed Zaborski

Figure 4. Dissected eggnest of periodical cicada. Each egg nest consists of two egg chambers, each holding up to 20 eggs.

a) dorsal view

Photo credit: Michael Jeffords

b) lateral view

Photo credit: Michael Jeffords

Figure 5. Physogastric *P. herfsi* female mounted in a permanent microscope slide next to the periodical cicada egg to which it was attached. Eggs hatch and develop to the adult stage in the distended abdomen of the physogastric female before she gives birth.

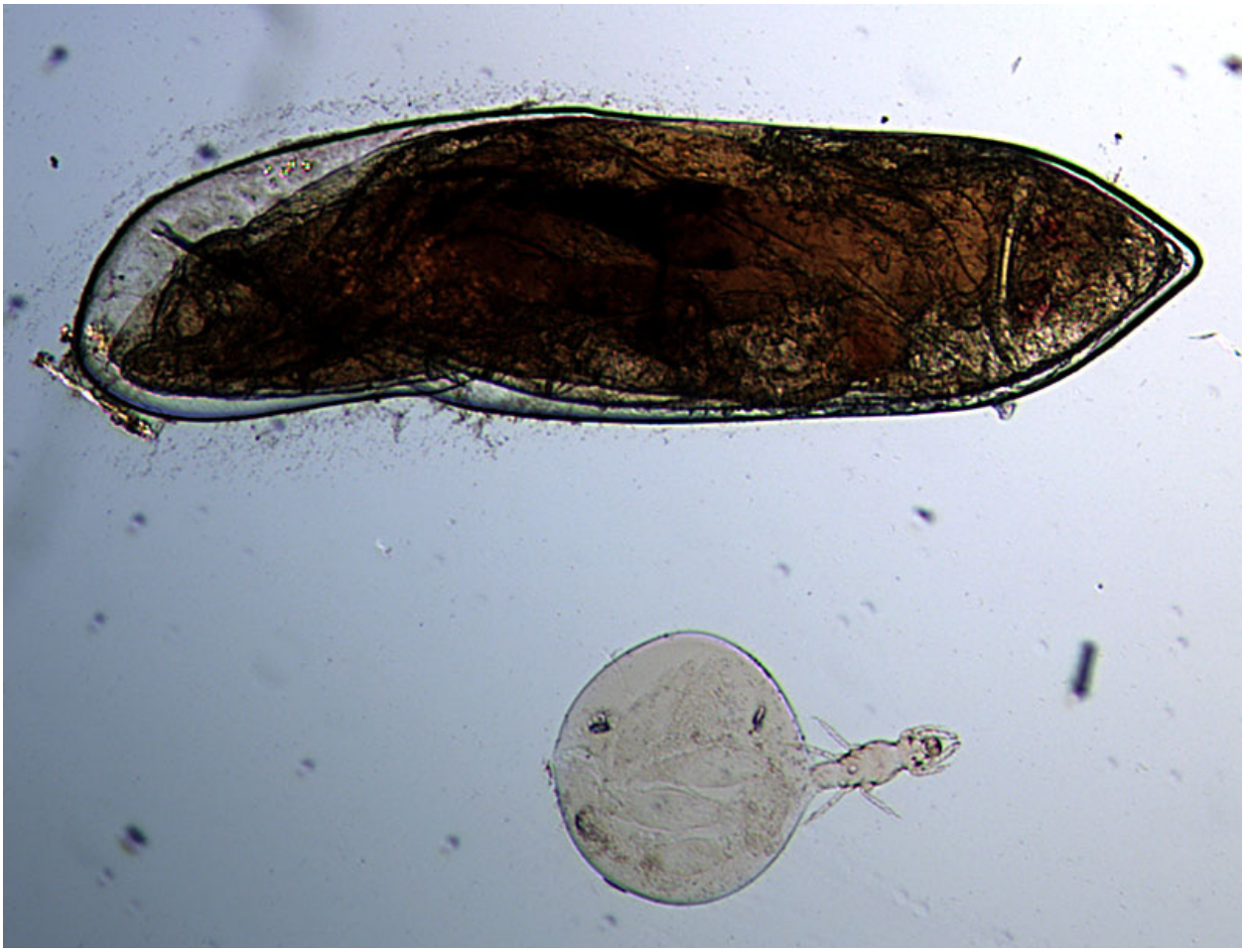

Photo: Ed Zaborski

Figure 6. Periodical cicada eggnest showing complete mortality of eggs and hatched nymphs following parasitization by *P. herfsi*.

Photo credit: Michael Jeffords

Figure 7. Physogastric females of *P. herfsi* cultured in the laboratory using pupae of *Pachysomoides* sp. as host.

Photo credit: Michael Jeffords

Figure 8. *Pyemotes herfsi* (Oudemans, 1936), female, *ex.* periodical cicada eggnest, Illinois, 2007.

a) dorsal

Photo credit: Ed Zaborski

b) ventral

Photo credit: Ed Zaborski

Figure 9. *Pyemotes herfsi* (Oudemans, 1936), male, *ex.* periodical cicada eggnest, Illinois, 2007.

a) dorsal

Photo credit: Ed Zaborski

b) ventral

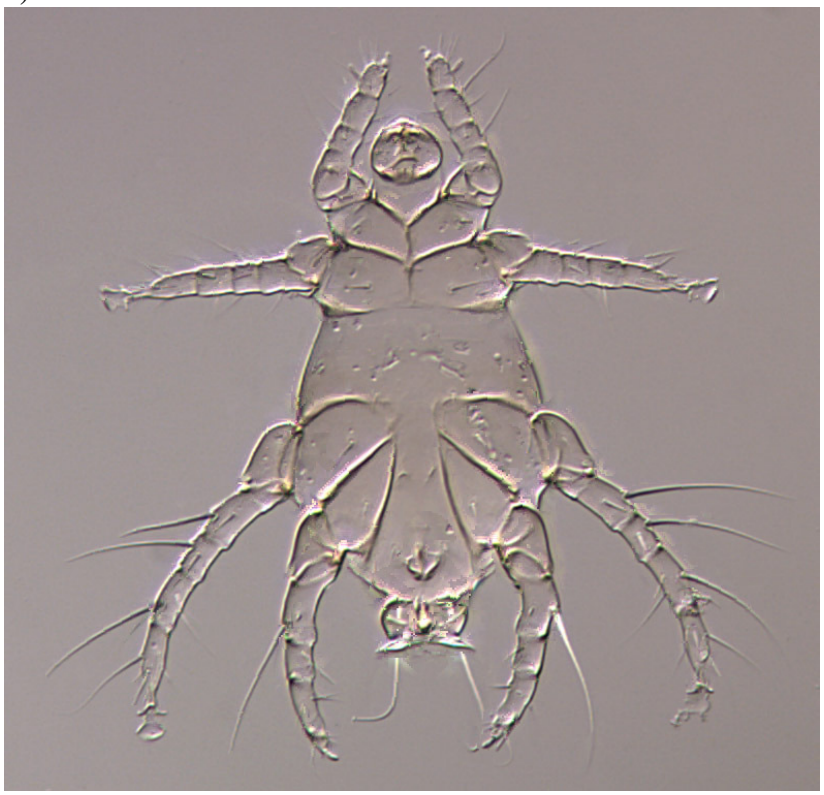

Photo credit: Ed Zaborski